**Advanced Aquaculture Technology**
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**Lecture 60**
**Mitigation and Adaptive Strategies (Contd.)**

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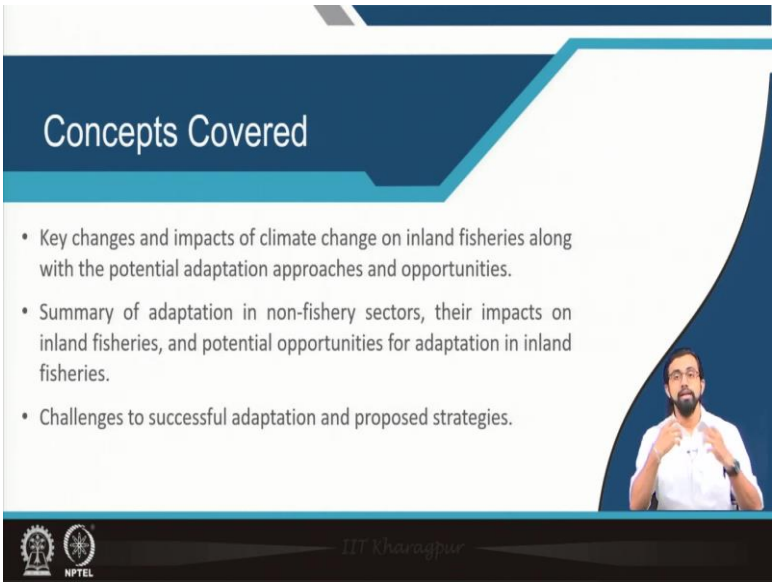


Hello everyone, welcome to the fifth lecture material of module 12 Environmental Consideration of Aquaculture. My name is Professor Gourav Dhar Bhowmick, I am from the Agriculture and Food Engineering department of IIT Kharagpur.

In this lecture material will be continuing with the discussion that we already had in the last four lectures about the impact of climate change on aquaculture. So, in this particular lecture material, I will mainly be focusing on the key changes and the impact of climate change on inland fisheries along with its potential adaptation strategies and opportunities and all.

If you remember in earlier lecture, we discuss about the mitigation strategies and all. Here we will mainly be focusing on adaptation approaches and opportunities. We will also discuss about the adaptation in non-fishery sectors and their impacts on the inland fisheries and what are the potential opportunities for adaptation in inland fisheries regarding the same. At the end, we will conclude it with the challenges to successful adaptation proposed strategies and how we can mitigate those challenges will be discussed in details.

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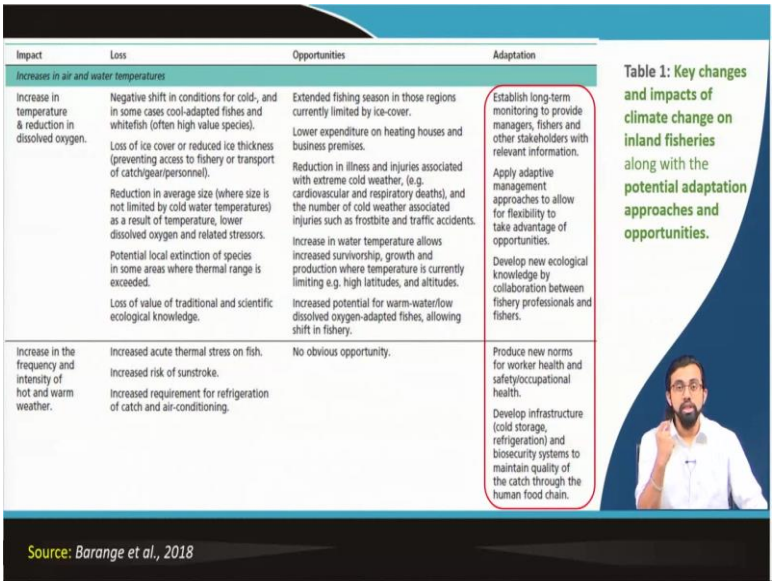


So, if you see in this table, we mainly like, we can see the different key changes and the impacts of if you see the left most column is the impact of climate change in the inland fisheries and their loss and the opportunities are given and at the end it is discussed about the adaptation strategies. Just to give you one example suppose, because of the air and the water temperature which is getting increased because of the climate change activities and all over the world.

Because of that what is happening it is because what are the loss that we are facing as a say suppose a beneficiary of inland fisheries, negative shift in the conditions for cold and some cases cold adapted fishes, loss of ice cover and which because of that the reduced ice thickness which actually prevent the access to fisheries and transport of catch and gear personnel in the polar in a mostly in the Arctic regions and Antarctic regions, reduction in the average size of your catch, potential local extinction of the species as is happening because of the changes in the temperature and all.

Now, we already discussed in earlier lectures in in detail about all these parameters or the losses or the cons part of it once the temperature is getting changed because of the climate change. What are the opportunities, it always lies there is always other side of the coin so it is always like that.

So, because of these changes in temperature, in the temperate and the Arctic regions people are now can do, go for fishing for more amount of time in a particular year because earlier it

used to cover with the snow and ice sheet, but now, as because of the temperature changes, those ice sheets are vanished and those snow cover is not anymore.

And at least it was there it is there for a shorter period of time in a year. Because of that what is happening larger amount of fishing season. The fishing season is getting extended, expanded or extended. So, there people can go for maximum amount of catch in the capture fisheries sector. It also lowers the expenditure on heating the house and the business premises, if you relate to the aquaculture, aquaculture farm and the hatchery designer hatchery structure and all. So, what happened, we do not need to provide it with a much of a heating or cooling systems, especially the heating systems in this particular scenario.

What are the adaptation strategies that we need to follow to get rid of to minimize the losses or minimize the any future effect on your system. You have to go for establishing long term monitoring to provide your managers, your fishers and your stakeholders with the relevant information. There should be proper adaptive management approaches that should be adopt and apply in your farm in your inland fisheries or you go for deep sea fisheries, which will allow you to flexibility to the advantage of the opportunities or any possible calamities that is that can be forecasted from before that it will definitely happen with just a matter of time.

And if you are having ready with your adaptive strategies or the management approaches, definitely it will be beneficial for you. You can develop new ecological knowledge about by collaboration between the fishery professionals and the fisheries so that they will the fisheries they will utilize the technologies which are very up to date on the cutting-edge situation right now. People can use those technology and adopt it even before any future event will take place which can cause some disruptive changes in the existing conventional technologies and conventional way of fishing.

Increasing the frequency and intensity of hot and warmer weather we discussed about El Nino, La Nina and all in earlier discussion, earlier lecture where I told you like, how these different changes in the climate scenario are affecting the aquaculture in general. So, if you see again like the loss is like in the increase in the acute thermal stress on fish, it increased the sunstroke, increased risk of sunstroke in a requirement of the refrigeration of catch and air conditioning is increased and all.

There is no obvious opportunity has been found with this kind of natural calamity or disaster to occur. Because of these changes in intensity of hot and warm climate weather in the in an

area, which is surprising for it to have in general. Like in European countries nowadays, like in for last couple of years, the temperature is rising like anything, which is not even like in the last 10 years, I think at least 5 to 6 years of out of this 10 years in the last decade was considered as one of the top 5 hottest year ever recorded in a European continental point of view.

So, it is like very rare, lot of climate change is actually real and it is actually changing the behavior weather pattern like anything because of that climate is changing and has this drastic effect on aquaculture. And how we can adapt it, we can produce new norms for the work on health and safety details, we can develop the infrastructure like cold storage or refrigeration unit or biosecurity systems to mainly to enhance them to maintain the quality of the catch through the human food chain.

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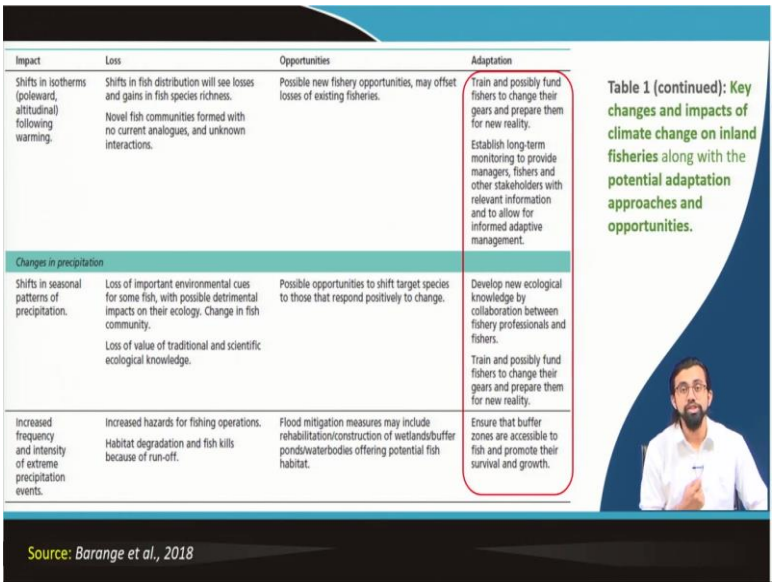

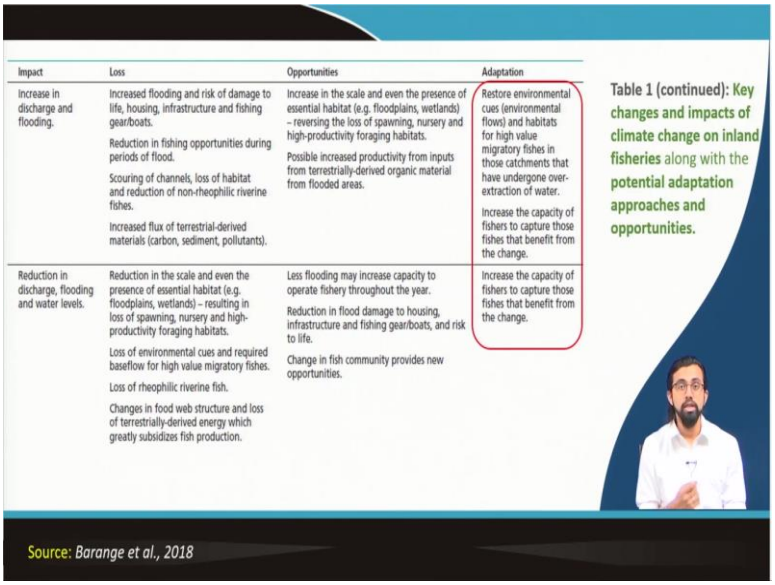


Shift in isotherm the poleward or the altitudinal or which is causing the following warming. You know what is isotherm? Isotherm is a line where you have the similar temperature. So, this isotherm supposes earlier 30-degree Celsius isotherm was there at that particular day of on year, suppose over Madhya Pradesh just to give you one example over the Madhya Pradesh just in the middle of India.

Suppose after but during what you will witness suppose in the next year, it is supposed to be in the Madhya Pradesh over Madhya Pradesh, but it is over now Uttar Pradesh it is going towards it is sorry, it is going towards I am doing it another word Madhya Pradesh to suppose it is in Karnataka towards the like the any shift in this change any shift in the, in this isotherm is detrimental, but specifically if it is changing towards the polar side more in the polar side, like in the first scenario Madhya Pradesh to Uttar Pradesh it is like in the polar side like we are in the northern hemisphere. So, the more north you go it is more polar side.

So, just to give you some example do not it is not the actual scenario. And the more you go to the polar side or more you go to the altitudinal. What do you mean by altitudinal, suppose in general, at a particular moment of time say like at a particular day of in year, the temperature line, this isotherm should be there at thousand-meter height, say like 20 degrees Celsius at thousand-meter height with air because of the climate change, instead of 1000 meter these 20 degrees Celsius or isotherm line is now at 1500 at say like a below than that.

Obviously, because like because the temperature is increasing at that particular height 100,000 meter now, the temperature isotherm is 25 degrees Celsius, because the temperature

is changing. So, theoretically it should be having 20 degrees Celsius, but now, the isotherm is getting isotherm is 20-degree Celsius isotherm is now in suppose in 900-meter height. Because, that 1000 meter it is already reaching the 25 degrees Celsius because of the temperature change.

So, this is just to give you some idea how it works, this shift in isotherms. Because of that what is happening shift in fish distribution is happening in novel fish communities are formed with no current analogues and unknown interactions and all and it can come up with some possibility or possible opportunities like new fishery opportunities which can offset the existing fishery problems.

And what are the adaptation technology that we can do? We can train and possibly fund the fishers to change their gears and prepare them for new reality and that particular place that they are normally go for culturing or like their culture I mean, like their rearing species.

We can establish a long-term monitoring to provide the managers and fishers with the information that will allow them to adhere to the most in advanced adaptive strategies in the management system. Changes in the precipitation, shift in the seasonal pattern of the precipitation, it does have a drastic effect on the aquaculture, because in aquaculture most of the pond you like what happen say, most of the inland fisheries they detrimentates.

Even a couple of years back even on tickets back also people are mostly depending on the temper mostly depending on the season, rainy season and the rainy season they reserve the water and that water it enriches the groundwater and that groundwater once the rainy season will go settle in the winter people will like they are expecting the groundwater to recharge their pond and it depends what type of pond it is groundwater based pond, rain water based pond, pond depending on different types, but in general rainy season and the season is one of the major factor of enriching, the supplying the water fresh water for your pond, if it is a very huge size, extensive aquaculture pond.

However, with time the precipitation pattern is changing, the place where it used to be a huge amount of rainfall even 10 years back also now, it is facing drastic drought and the other place where it is supposed to be drought and it is a desert area, they are facing drastic, huge amount of rainfall of precipitation in certain like with very uncertain manner.

So, that is happening it because of this, it has an impact on the aquaculture production around. So, but how we can adapt we can develop new ecological knowledge, by

collaboration between the fishery professional and fishers. We can train and possibly fund the fishers to change their gears and to prepare them with a new reality.

This increased frequency and the intensity of extreme precipitation event, it is simple mostly the cyclonic event like strong event and all suppose like flood situation, drought situation. All the situation does have a impact on aquaculture production of your farm whether it be inland from inland fisheries or just have a major impact.

Because the availability of water because of the availability of other sources transportation everything can get halt. So, you have to ensure the buffer zone which are which has to be accessible for fish and promote their survival and growth for any kind of scenario, the water should be there and a particular quality so that fish or your culture will sustain any situation.

So, increase in discharge or flooding situation you have to restore the environmental cues or the flows and habitats and high value migratory fishes in those catchments. Those have the under can the over extraction of the water. You can increase the capacity of fishers to capture those fishes that benefit from the change. Reduction in discharge and flooding and the water level what is the adaptation strategy, you have to increase the capacity of fishers to capture those fishes that benefit from this kind of changes and all.

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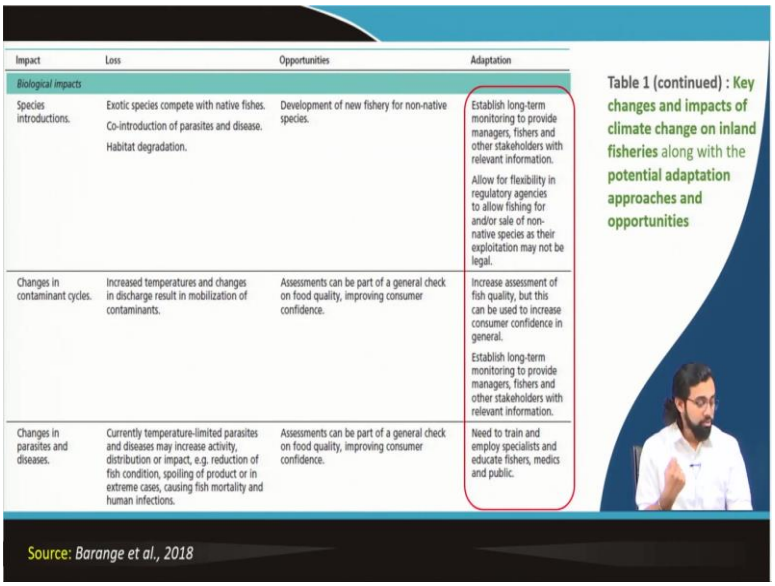


What do I mean by the like biological impact? There is some biological impact also because of the changes in climate change. What is happening, new species introduction is happening,

why I am saying this new species introduction because of say the climate change, what is happening because of the storm events are happening, because of the changes in the oceanic event, which led new species to introduce to a particular ecosystem. And in that particular ecosystem for them, it is a exotic species.

So, what will happen they have a competition because of the native fish and the say exotic fish, this exotic fish can be the predator of the native fish, which can completely damage the whole ecosystem. On the other way around maybe, the exotic fish is very much rich with the nutrients and all and your native fish will they will be very happy and they will be having new food on their production will can increase anything can happen. So, this comes under the loss and opportunity of this kind of situation or how to set this event.

So, what can be the adaptive strategies, we have to establish long term monitoring to provide the all the stakeholders with the information relevant information about the possible changes that may happen in future and you have to allow for the flexibility in the regulatory agencies to allow the fishing of non-native species as their exploitation may not be legal, but they can have some flexibility because that this non-native species can be risky for your native species. So, you can go and you can capture them in a special case basis, case to case basis.

Changes in the contaminant cycle increase in the temperature and the change in the discharge it results in the mobilization in the contamination, those contamination can be bio accumulated and can be transferred to human body itself. Can it possible, because from the fish, it will go to the higher portion and from there maybe from us or maybe directly from the fish? So, the same way, the better is to go for increase in the assessment of the fish quality and to increase the consumer confidence in general and they can start having the fish.

So, that is more important and also you have to establish a long-term monitoring to provide any kind any changes or you can provide the sensors and all in a different places. So, we will get the real time information about the contaminant the pollutant level of your water of your like farm water, where your culture species is being reared. Changes in the parasite in the disease, definitely different new temperature limited parasites are coming into the action because of this climate change.

And earlier those species are not this body or then, they are how to say they are in there is safeguard system that they have. There their immunity is like a not build up for this kind of parasites to tackle and to handle this. So, because of that you need to introduce some like

medicinal application so that your fishes or your fish or whatever the aquatic species you are culturing, they can be they can sustain in those kinds of adverse situations and all. So, that is why you need to train and employ the specialist and educate the fisher medics and the public in general with this kind of businesses.

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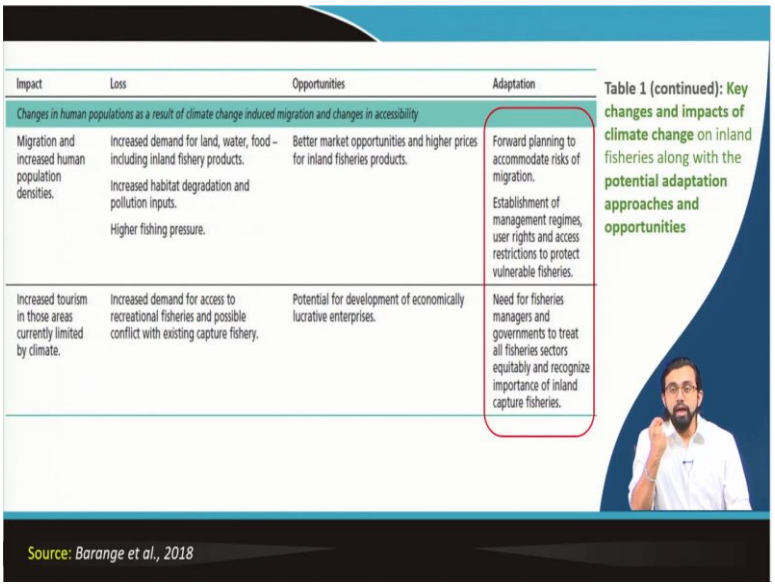


What are the changes in the human population, how it can affect the aquaculture, the migration and the increased human population density? First of all, most of the like nowadays, if you go back 3 to 4 decades back also and now that changes in the population in the sea and population in the cities, and population in the urban and rural areas is changing like anything a drastic shift from the rural area to the urban area is happening, a lot of people are now focusing on a very specific regions in this very specific places, which has very high employability and all this.

There are different reasons because of the resources that is available in that place. So, this shift because of this population change or population density changes in the population density, some places becoming populationally very dense and some spaces becoming much lighter, it is not as dense as it was earlier. Both the cases it has effect on the aquaculture because the aquaculture production, it depends upon the demand upon the market demand.

So, if the market demand is changing time to time, so, based on that, you have to strategize your plan in such a way so that it will not get harmed even if the population is getting shifting from one place to another. Another impact is likely to increased tourism in those areas which can currently limited by the climate because the changes in the tourism if you see that like no

tourism businesses very much depend because suppose if you are having tourists from European region in India in a specific place, what will happen people are from say like European in general, I am just giving you example a very generalized discussion.

So, they are very much fond of sea fish, any fish in general. So, for them, we need to prepare our place with the amount of because the demand is very high, because that place is very much famous for the particular type of people who like to have a fish, who like to have a sea fish, who like to have fish in general whether it be inland or sea fish.

So, for them you have to category you have to generalize your market in such a way and also you have based on that based on the market demand you have to make sure that demand is fulfilled by from your farm, from designing more amount of farm, from establishing more amount of farm in the nearby areas.

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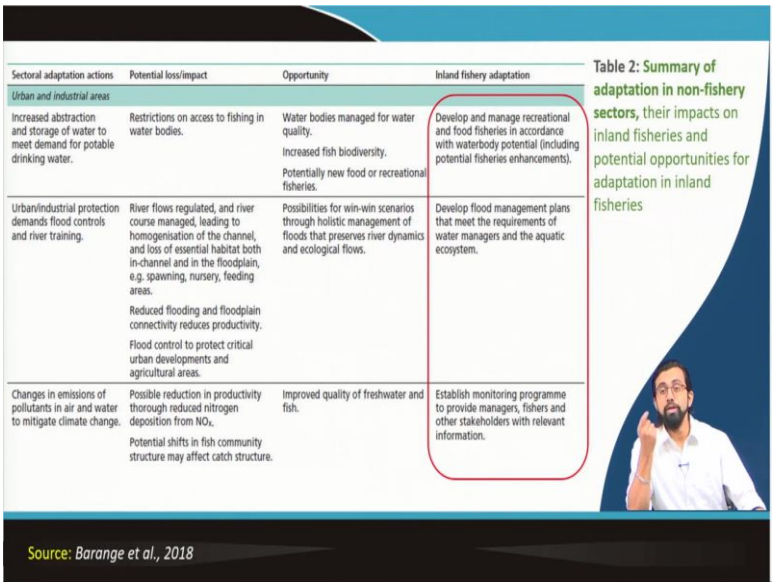


So, these are the different adaptive strategies that we can adhere to with the change in this, because of the climate change and the fishery sector. What happened to the non-fishery sector? I mean like the because of the climate change, the non-fishery sectors are also getting affected, how they can somehow passively affect the aquaculture as well. Suppose an urban and industrial areas what is happening, say like increase in the absorption and the storage of water to meet the demand for potable drinking water.

So, which is not directly related to your aquaculture, because it is like extracting more amount of water from say a particular source. It can be a surface water source, it can be a groundwater source, whatever it is, it is extracting the water which is not the same amount like it was before. So, before the aquaculture before your aquaculture they were even having ample amount of supply, but because of this change in this abstraction in the storage process, because of the supply of the potable water, what is happening? The water availability getting reduced.

In that case you have to develop and manage a recreational and the food fisheries in accordance with the water body potential. So, that has to be well developed from the, you have to be preplanned it according to the forecast that you can receive from the experts. Urban and the industrial protection and the demands of protection demands for flood control and the river training and because of that, it is like you have to develop proper flood management plan that meets the requirement of the water managers and aquatic ecosystem.

Changes in the emission of the pollutant in air or water to mitigate the climate change. And because of that, you have to establish how we can adapt you have to establish a proper monitoring program to provide all your stakeholders with relevant information with any minor changes. So, once these changes is happening, your system should be ready with the adaptive strategy, system should be ready by them the moment it will change in actual scenario

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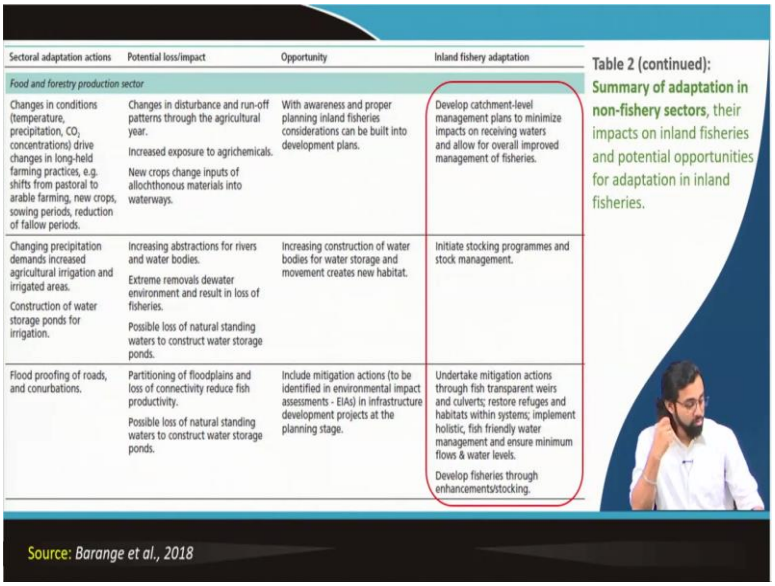

Changes in the food and forestry production sector say like changes in the conditions like temperature precipitation, carbon dioxide concentration, which actually helps shift from pastoral to arable farming, new crops, sowing period, reduction of fallow periods all these changes in the agricultural sector. How it is actually relevant to the aquaculture, because this changes in this agricultural factor are actually very much involved with aquaculture, because they are all interrelated in terms of resource in a particular place.

People are resource constrained it is not that unless until you are a providing exporting or importing from outside mainly your resource constrained in a particular place, you have a very meaning like exact amount of resource which has to be diverted to agriculture and aquaculture in a similar way or say like in a particular ratio for a certain reason, if your agriculture is blooming or agriculture is like resource need is like blooming, what will happen it will have an impact on your aquaculture sources.

So, you have to develop this catchment level management plan to minimize the impact of the receiving water and you have to allow for an overall improvement management in the fishery sector that can be the adaptation strategy that you can follow. Changing in the precipitation demand which increase the agricultural irrigation and irrigated land and the construction of water storage pond.

For irrigation, you have to initiate the stocking programs and the stock management from the beginning in your aquaculture that can be your adaptation strategy. Flood proofing of road and these conurbations are not because of that what will happen? We have to undertake the mitigation actions to the fish transport weir in between or select culvert structure in between this flood proofing road.

So, at least this the fish it will not be considered as a refuge it will it can easily go to its habitat within the system and by this fish friendly water management and the insured which can ensure the minimum flow and water level and has to be properly developed so that fish can easily move from one place to another.

So, these are the adaptation strategies that you can develop you can adapt for this change in order to adapt with the non-fishery sectors the adaptation in the non-fishery sector and based on that their passive adaptation will be will look like this inland fisheries point of view.

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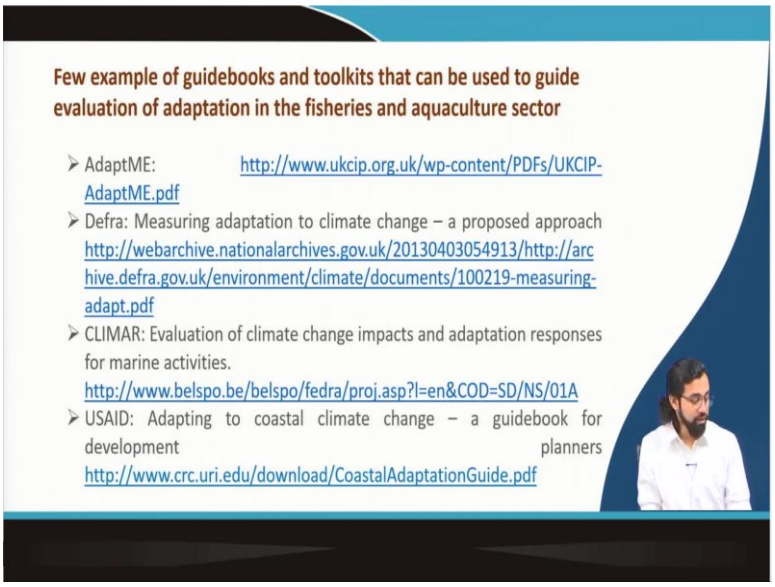


These are the examples of the guidebooks and the toolkit that you can use to how to say like in the fisheries and aquaculture sector at AdaptME, Defra and CLIMER, USAID, so, these are the I think you should take a you can take a click and you can search for it, this contents are very useful. It will give you a very nice information. It will enhance your knowledge about the adaptation strategy and all whatever I have discussed. This will definitely help you to understand it much better way.

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So, what are the challenges to the successful adaptation and the proposed strategies are there which like I have already discussed in the last 2 lectures in general. So, you know, the adaptation why we want to go for adaptation to start with you remember. It is the most practical short-term solution to the climate change. However, the implementation may face some various types of challenges.

One of the major more important most important challenge includes the failure to acknowledge the climate changes, which will have different effects on the producers based on the climate factors like their specific environment and the region, the knowledge regarding the climate change, community dynamics, population, economic condition in the present industrial scenario.

All this knowledge has to be there and you have to acknowledge the changes in the climatic situation that is the problem, you know, I am feeling bad to say we are very much advance the human civilization, we when call the science program, it is advanced like anything, but still maximum part of the population does not believe in climate change. And they this do not bother about the changes that is happening in the climate and then they keep doing the notorious stuff that are keep that are repetitively delivered by the experts to not to do.

They are keep on saying to do this, this, this, in fact, this you have to you have to change, you have to do some behavioral change in order to adapt to the climatic changing situation, and you have to reduce the effect anthropogenic effect on the climate change situation, but it is not being followed, it is not being acknowledged by majority of the population.

It is a failure of the policymaker, it is a failure of the education system, I would say, but, definitely, I am hopeful like people are changing, things are changing, and it will within a couple within very soon, people will be like each and every one will be very much adhered to the problem that is associated with the climate. They will acknowledge the change that climate change scenario, and they will do the best of their ability to retrieve the situation to somehow make the world in a bit better place again.

Other than that, the biased and unrealistic assessment of the potential risks associated with climate change may deceive the policymakers and the aquaculture producers in taking the necessary precautions, because sometimes it what happened people do follow fake results, fake information, even suppose a scientist very famous, very renowned expert, when they do research maybe because of certain problem because every person is, they are supposed to do

a it is not something impossible for like, it is not something it is not people are not computer they do make errors, they do make mistakes.

Because of this mistake, because of certain mistakes or certain mistakes in calculation and all, the end result that has been shown by the experts or the scientists to the policymakers may deceive them, so that they will keep on adapting the strategies based on the results that results which are erroneous. So, this is also a problem that it has to be cross checked by 2, 3 different other experts or other educational body or an institution. So, to be 100 percent sure about the, this assessment results and all, and based on that, the policymakers should act accordingly and at the earliest possible.

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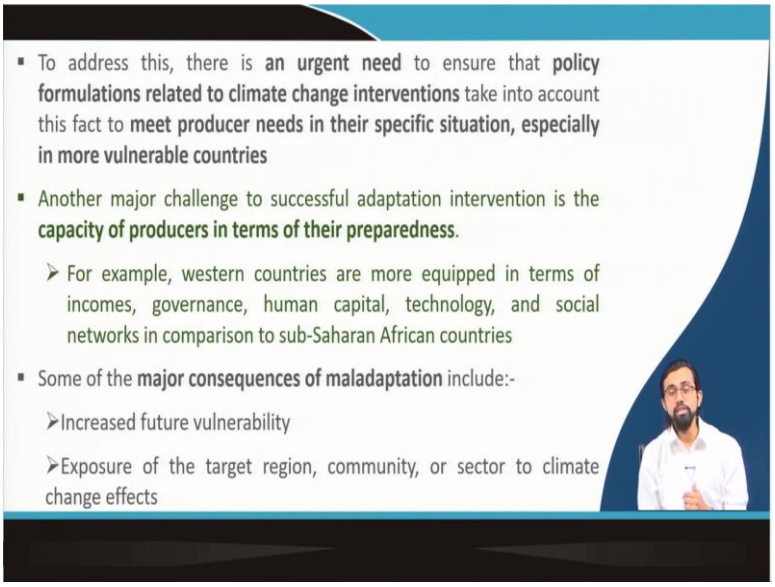


Though, other than in order to address all those things, there is an urgent need to ensure that the policy formulation related to the climate change interventions like to meet producer needs, in their specific situation especially in more vulnerable countries. Another major challenge to successful adaptation intervention is the capacity of producers in terms of their preparedness. Suppose in a Western country, if you ask them so you are not supposed to use this kind of gear, it can affect this or supposing you cannot suppose he is having one steamer or fish catching a vessel.

So that vessel all of a sudden new regulation come and they say like no, you are not allowed to have this kind of this particular type of pump in your vessel, you have to change the motor, you have to change the type of oil, you have to change the type of gear that is used. They can

do that because they are rich, suppose so in case of rich in Western countries, they can do that, but all of us are going to say the same to sub sub-Saharan African countries.

They cannot just do that though they understood the fact though they understand that their steamer, their fish catching vessels are causing some environmental problem, but they cannot add up, they cannot, they just simply cannot go ahead with the alternate solutions, because they are not having enough money enough support to in a go ahead and change with a new vessel that easily.

So, definitely and also the preparedness is also not ready because they are very much, they are not susceptible to the change because they are having the problem with the monetary. There are other sociological point of view as well. So, these are the reason this preparedness is very important. And that is normally shown that in Western countries, they normally can adopt with the new situation very fast, and they do it very frequently, which is not as same in all the sub-African countries.

It is not a generic statement, I am not giving a generic statement, it is just from overall point of view, but definitely it does, does have a lot of exceptions, it does have a lot of maybe some in some scenario it is like other way around. But it is a general survey report by the evidence is presented in front of the experts. Some of the major consequences of this maladaptation are like increasing the future vulnerability and exposure to the target region and the community and the sector to the climate change effects.

So, if you do not use proper adaptation strategy, proper mitigation strategies other than that, we are bound to face the changes in the nature because nature is changing, everything is changing, like we are also bound to evolution, everything is changing and we have to be prepared for this change.

Some changes can be minimized like this climate change, because this is happening in a very faster way than it is supposed to do, because of our foolishness. We can redo the things we can sometimes we can do some practices, which can have a rather forget about negative rather positive effects. So, this way we can reduce these effects and these consequences of climate change on the aquaculture practices.

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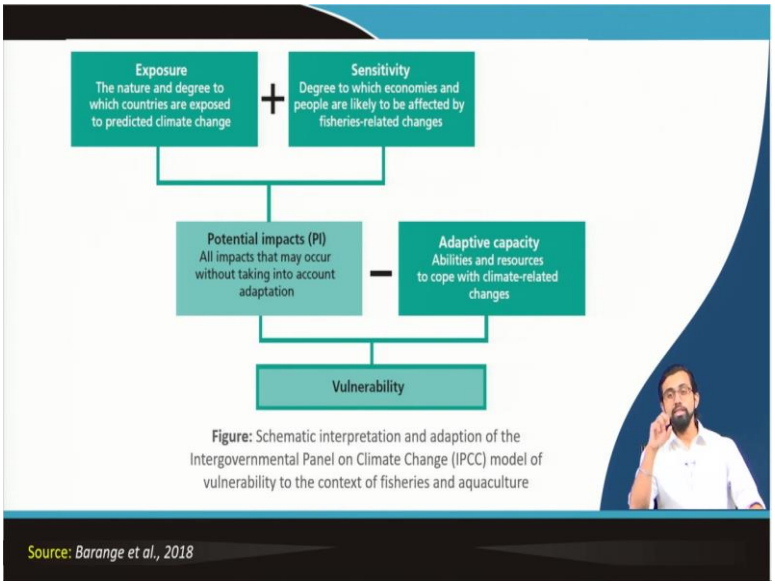


This is the schematic interpretation and adaptation by the Intergovernmental Panel on Climate Change, IPCC a you have heard of it. It is an international body who and which, gave this model of vulnerability to the context of fisheries and aquaculture. See the exposure first, the nature and the degree of which countries are exposed to the predicted climate change and the sensitivity. Degree of which economics and the people are likely to be affected by the fishery related changes.

This both will have a potential impact of, in short, we call PI, these impacts may occur without taking into account adaptation. Adaptive if we have the adaptive capacity, like abilities, and the resources to cope with climate related changes this if we subtract these 2, we will get the vulnerability situation. So, this is how it looks like. It is like G stop all the discussion that we had in the last 2 slides.

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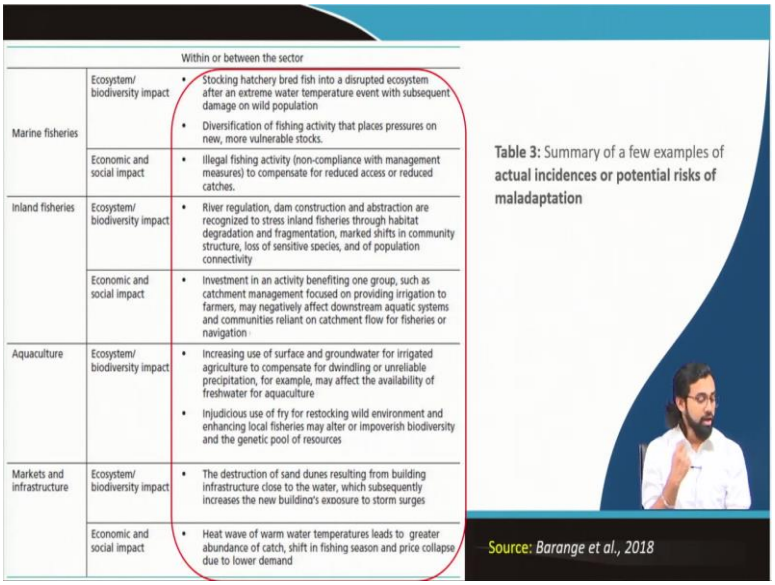


Here, I have given some examples of actual incidences or the potential risk of maladaptation. In the marine fisheries, the stocking hatchery, say what will happen in the marine fishery maladaptation.

Suppose you are having a change in the ecosystem and the diversity impact point of view if I say, if you are talking a hatchery breed fish into a disrupted ecosystem after an extreme water temperature event, which will have a subsequent damage in the wild population as well, because you are stocking it in a disrupted situation and then you will release them it will definitely affect the wild population in a later stage.

Diversification of the fishing activity that places where which because of the it will put a pressure on the new and the more vulnerable stocks like economic and social impact, illegal fishing activity in a noncompliance with the management measures to compensate with the reduced access and reduce catches in general. Like if you talk about the market and infrastructure, say about the ecosystem and the bio diversity basically. The destruction in the sand dunes, resulting from the building infrastructure close to the water which subsequently increases the new buildings exposure to the strong surges and all.

Economic and economic impact or the social impact heatwave of one motor temperature leads to greater abundance of catch and shift of fin fishing season and price collapses due to the lower demand. So, your adaptive strategy has to be properly valid. So, otherwise, what is happening this kind of scenarios may we may have to face because of this maladaptation practices.

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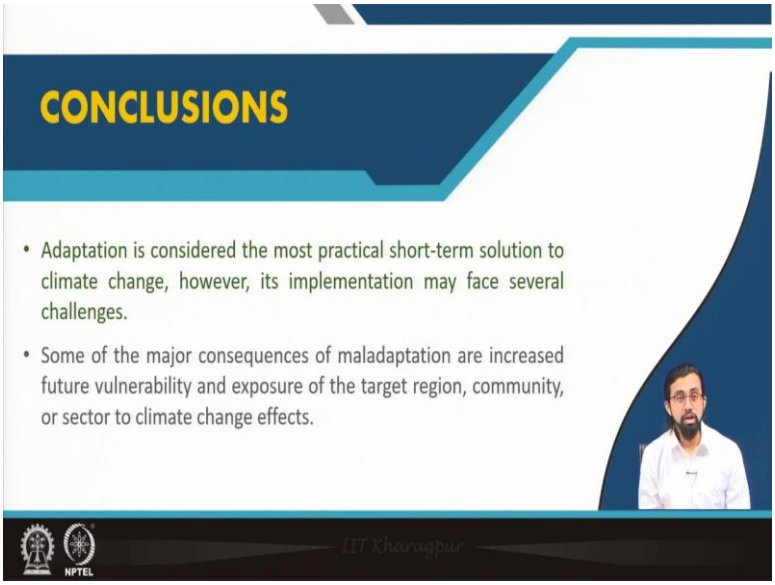


So, anyway so, in conclusion, I would say like, we already discussed that, what is adaptation? It is a short-term solution to climate change. And what are the major consequences of maladaptation, which definitely it will increase the future vulnerability and exposed to target region, community, and the sector to the climate change effects.

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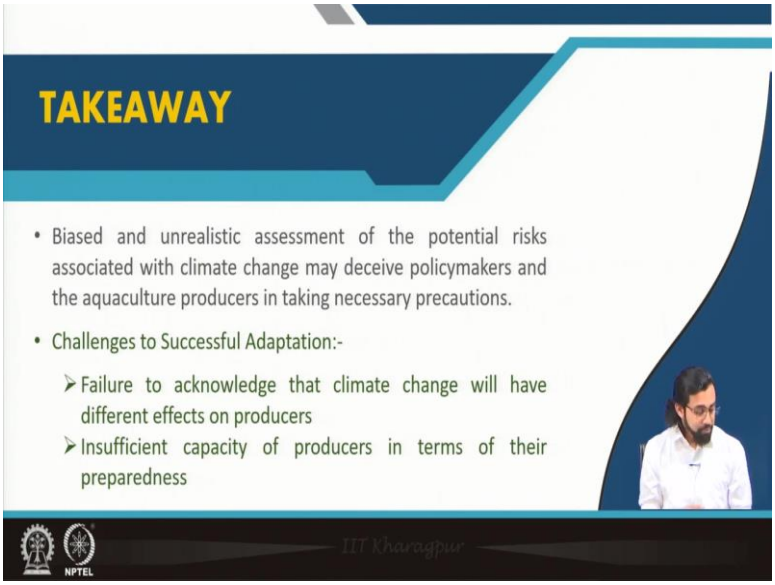


And one of the major takeaway message from this lecture one of the last lecture material is like, biased and unrealistic assessment of the potential risks associated with the climate change may deceive the policymaker, and also aquaculture producers in taking necessary actions or precaution. So, you have to be very much cautious about this assessment results and maybe you can do cross checking and multiple cross checking by different experts.

Challenges that we that we normally face for successful adaptation strategies are mainly failures to acknowledge that climate change will have different effects on producers and also insufficient capacity of producers in terms of their preparedness and because of the changes in their economic status, because of changes in their political status and et cetera.

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These are the references that you can follow to get more idea about to more information about the change about this particular sector. I hope you get to know about like you were helpful about getting all the with the information that we have discussed in the last 5 lecture in this module, that how climate change is happening and how it is, it is actually having this drastic impact on the aquaculture.

And this aquaculture, how what are the strategies that we can follow to mitigate and also to go for some adaptive strategy, adaptive technology, adaptive strategies, so that we can minimize the harmful effect on aquaculture, this climatic event and all climatic anomalous.

I hope you get to learn something new, something really informative and you will practice it you will use it in your firm, your design your future, like the place where you will be employed or suppose you will be sharing employment as an entrepreneur. So, in all the cases you will implement all these strategies and all the precautions that we have discussed in last few lectures. And it will definitely help you and it will not only help you but it will help the

whole human civilization because each drop matters. So, that is it for this lecture matter. Thank you so much, bye.